European Commission

JRC TECHNICAL REPORT

EU project UPGRADE (No 724036) - measurements of a Jeep Renegade prototype vehicle by JRC

Cologna M., Lahde T, Forloni F., Lesueur D., Le Lijour P., Giechaskiel B., Martini G.

2019

Joint Research Centre

EU Science Hub
https://ec.europa.eu/jrc

JRC117809

EUR 30007

PDF ISBN 978-92-76-14095-5 ISSN 1831-9424 doi: 10.2760/91708

Luxembourg: Publications Office of the European Union, 2020

How to cite this report: Cologna M., Lahde T, Forloni F., Lesueur D., Le Lijour P., Giechaskiel B., Martini G., *EU project UPGRADE (No 724036) - measurements of a Jeep Renegade prototype vehicle by JRC*, EUR 30007 Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-14095-5, doi: 10.2760/91708, JRC117809.

Contents

Abstract

Within Work Package 5 of the H2020 project UPGRADE (High efficient Particulate free Gasoline Engines) http://www.upgrade-project.eu/, JRC tested a demonstrator vehicle specifically developed by Centro Ricerche Fiat (CRF) in WLTP conditions. The results showed that:

1. All pollutants were below the EURO 6 limits.

2. Particle number emissions were two orders of magnitude below the limit of 6×10^{11}/km. PN10 were in average 13% higher than PN23.

3. CO_2 emissions were on average 165.3 g/km.

1 Introduction

The H2020 project UPGRADE (High efficient Particulate free Gasoline Engines) www.upgrade-project.eu, contract no. 724036, coordinated by Centro Ricerche Fiat (CRF) aims at providing new knowledge and innovative technologies for the development of future high efficient and clean Spark Ignited GDI engines for post 2020 market introduction. Work Package 5 is devoted to the final assessment of the demonstrator vehicles, based on the independent testing carried out with the external collaboration of Joint Research Centre (JRC). For this reason JRC tested a demo vehicle Jeep Renegade gasoline in WLTP conditions. RDE tests were not requested.

The demo vehicle provided by CRF is based on a Jeep Renegade Gasoline 1000 cc, with gasoline particulate filter (GPF), modified by CRF for the UPGRADE project. It was tested according to WLTP in laboratory Vela 1, from July 15th to 19th, 2019.

2 Experimental

The tests were conducted in VELA 1, with 9 m^3/min CVS flow rate. VELA 1 is equipped with a single roller. The coast down values provided by CRF were (F0 142.5 [N], F1 0.630 [N/(km/h)], F2 0.0407 [N/(km/h)^2]. In total five valid repetitions were collected. The first three valid repetitions were conducted with the same coast down values (CD1). After cost down check, two more valid tests were conducted with new calculated coast down values (CD2). The results of the coast down tests were F0 64.3, F1 -0.588, F2 0.0486 for CD1 and F0 77, F1 -1.065, F2 0.0515 for CD2. The test cycles were WLTP with cold start. The values reported are the analysis of the diluted gases collected in the bags. As required by the regulation, for the WLTC, the sampling bags were filled with the diluted exhaust and were analysed at the end of the test. An analyser (AMA i60 from AVL) was used to measure the bags filled with diluted exhaust at the end of the test. The particle number measurement system connected to the dilution tunnel was the AVL particle counter (APC) 489 (AVL, Graz, Austria), compliant with the light-duty vehicle regulations. A condensation particle counter with 50% counting efficiency at 10 nm was added in parallel with the internal condensation particle counter with 50% counting efficiency at 23 nm.

The demo vehicle and following description of its characteristics were provided by CRF.

"The UPGRADE demonstration vehicle is based on a B-segment vehicle, JEEP RENEGADE, representative of an important market, equipped with the small downsized stoichiometric engine developed in the project. The new engine platform demonstrates how a downsized highly boosted engine configuration is able to further reduce CO_2 emissions and especially under Real Driving conditions with respect to the initial best State of the Art equivalent solution. To increase the engine efficiency it is necessary to ensure A/F ratio and spark timing for best efficiency even under high engine load, this mainly meaning to mitigate knocking phenomena occurrence. This approach has been obtained with stoichiometric combustion approach and developing the best combinations of technologies including advanced VVA/VVT capabilities, advanced boosting system EGR (Exhaust Gas Recirculation) and thermal management systems and implementing advanced fuel injection (direct) and ignition system supported by new dedicated control strategies that will be integrated in the ECU (Engine Control Unit) software. The engine is the result from the combination of several innovative engine technologies, covering new single hardware component development, systems integration and advanced control capabilities." Main vehicle and engine characteristics are summarized in Table 1.

Table 1. Main vehicle and engine characteristics, as provided by CRF.

Engine	1.0L 3cyl UPGRADE Engine
Power	120 CV @ 5500 rpm
Torque	190 Nm @ 2000 rpm
Geometrical CR	13
Intake cam	Extreme Late
After Treatment System	TWC + coated GPF
EGR System	EGR Sample before TWC & GPF
Turbocharger	Variable Geometry Turbine
Intake manifold	Aluminium
FIS	High pressure FIS Range 50 – 350 bar
Transmission	6-speed manual transmission
Weight	1245 kg

3 Results and Discussion

The results of the cold start WLTC are plotted in Figure 1. The averaged data are given also in Table 2, while Table 3 lists all the data for each single test, including coast down values and RCB correction criteria.

Figure 1. Results for WLTC (cold start). Lines show the Euro 6 limits for positive ignition vehicles. The bars show the average emissions with CD1 values (3 repetitions), CD2 values (2 repetitions), and the average of all tests (5 repetitions). Error bars are twice the standard deviation. All the values and difference between max and min are given in Table 1.

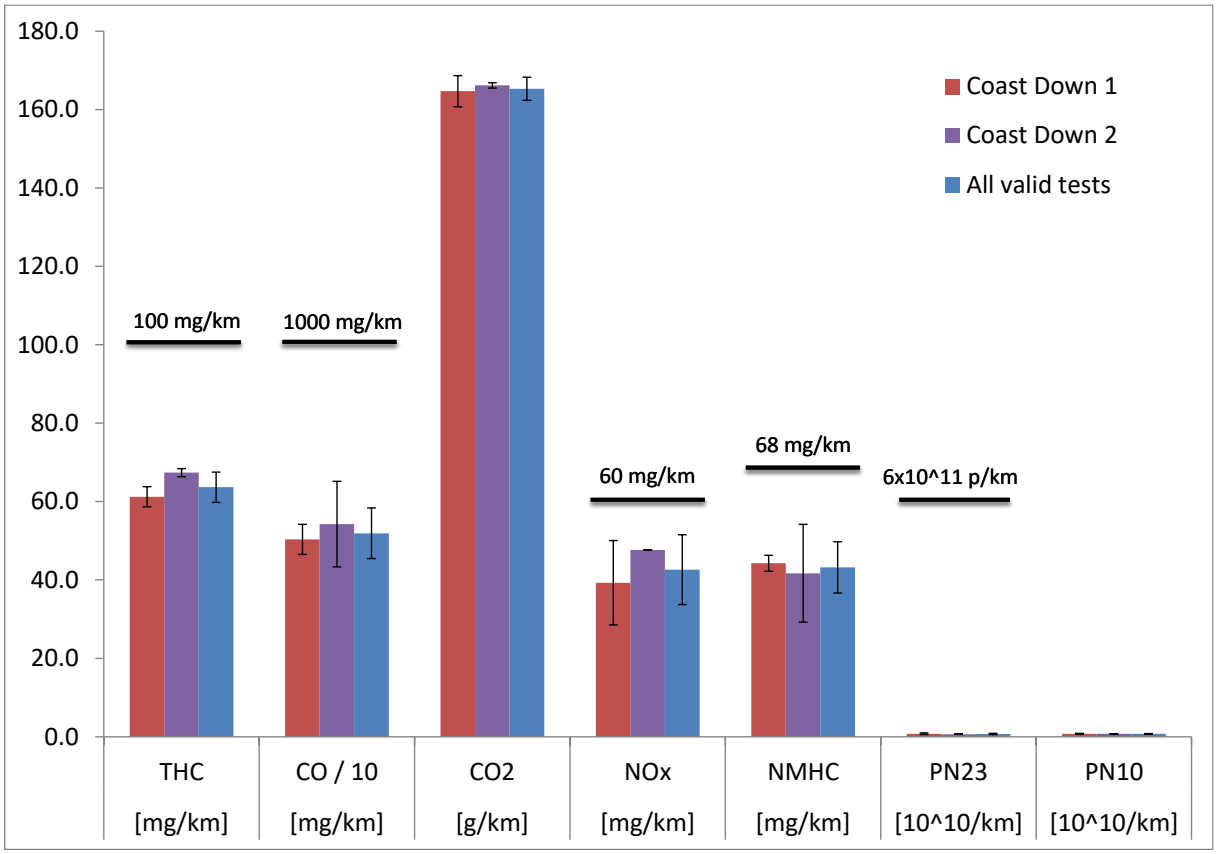


Table 1. Average emissions, standard deviation and difference between max and min for the WLTC cold-start tests. Data are plotted in Figure 1.

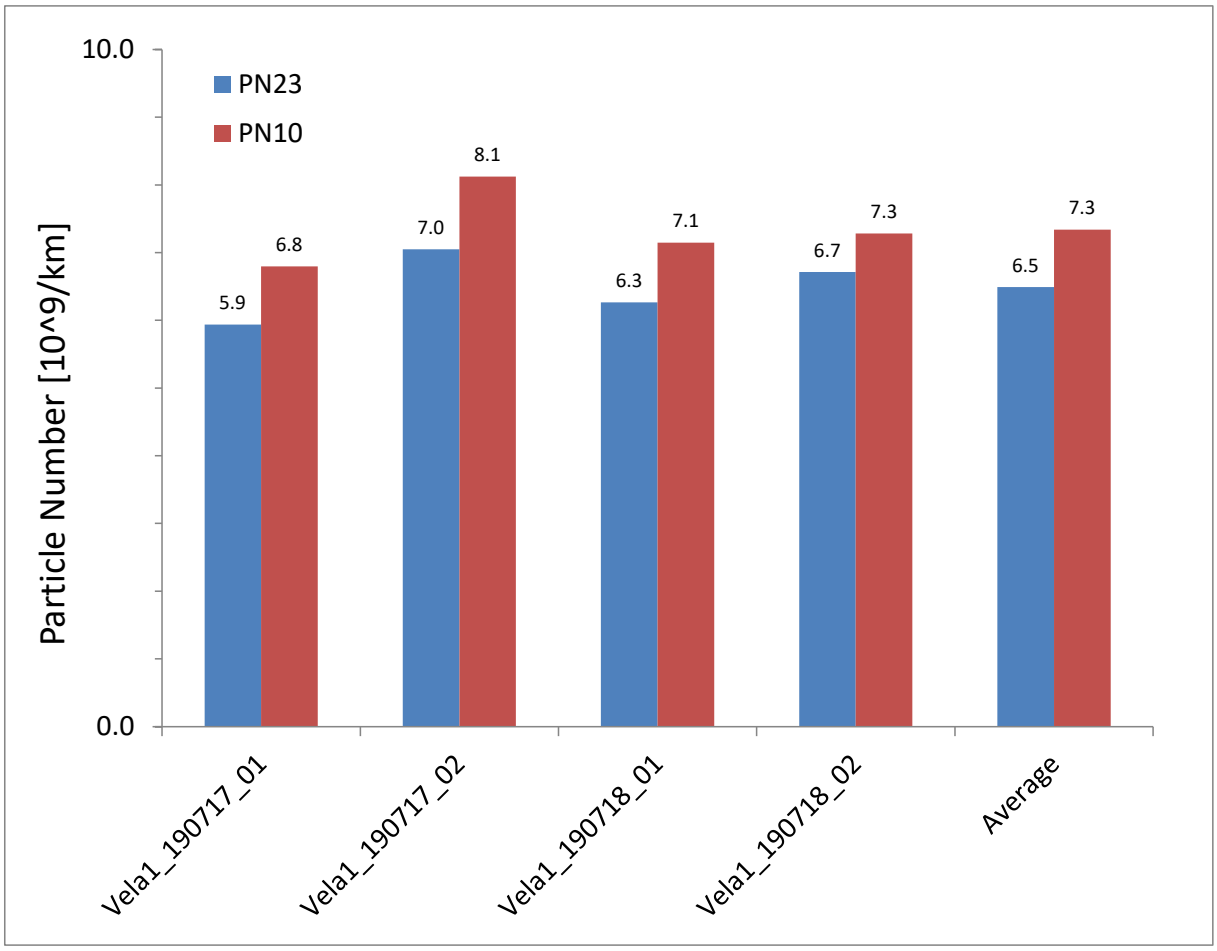
		Coast Down 1			Coast Down 2			All valid tests		
		Average	Std dev	Max-Min	Average	Std dev	Max-Min	Average	Std dev	Max-Min
THC	[mg/km]	**61.2**	*2.6*	*5.1*	**67.4**	*1.0*	*1.4*	**63.7**	*3.9*	*9.4*
CO	[mg/km]	**503.6**	*38.6*	*72.3*	**542.3**	*108.9*	*154.1*	**519.1**	*64.5*	*154.1*
CO2	[g/km]	**164.7**	*4.0*	*7.3*	**166.2**	*0.7*	*0.9*	**165.3**	*3.0*	*7.3*
NOx	[mg/km]	**39.3**	*10.8*	*21.5*	**47.6**	*0.0*	*0.1*	**42.6**	*8.9*	*21.5*
NMHC	[mg/km]	**44.3**	*2.0*	*4.0*	**41.7**	*12.5*	*17.6*	**43.2**	*6.6*	*17.6*
PN23	[10^9/km]	**7.6**	*2.0*	*3.9*	**6.5**	*0.3*	*0.4*	**7.2**	*1.6*	*3.9*
PN10	[10^9/km]	**7.5**	*0.9*	*1.3*	**7.2**	*0.1*	*0.1*	**7.3**	*0.6*	*1.3*

Table 2. Results for each test.

		EURO 6 limits	Coast Down 1			Coast Down 2	
			Vela1_190716_03	Vela1_190717_01	Vela1_190717_02	Vela1_190718_01	Vela1_190718_02
THC	[mg/km]	100	61.1	58.7	63.8	68.1	66.7
CO	[mg/km]	1000	547.5	488.1	475.2	619.4	465.3
CO2	[g/km]		160.1	167.4	166.6	166.6	165.7
NOx	[mg/km]	60	28.5	39.3	50.0	47.6	47.7
NMHC	[mg/km]	68	44.6	42.1	46.1	32.9	50.5
PN23	[10^9/km]	6*10^11	9.8	5.9	7.0	6.3	6.7
PN10	[10^9/km]		n.a.	6.8	8.1	7.1	7.3
F0	[N]		64.3	64.3	64.3	77	77
F1	[N/(km/h)]		-0.588	-0.588	-0.588	-1.065	-1.065
F2	[N/(km/h)^2]		0.0486	0.0486	0.0486	0.0515	0.0515
RCB corr. crit.*			0.0008	0.0026	0.0013	0.0020	0.0011
ΔCO2	[g/km]		0.4511	1.5259	0.7598	1.1725	0.6440

** If RCB correction criteria > 0.005, CO2 correction is applied*

Figure 2. Particle number emissions (PN23 and PN10) for the single tests and average of four tests.



For all the tests the emissions are always below the EURO 6 limits. In particular, the PN23 emissions are two orders of magnitude below the limit of 6×10^{11}/km, the average of five test being 7.2×10^{9}/km.

PN10 were also recorded, although not yet regulated. Data are available only for 4 tests out of 5. Discarding the first test, the PN10 emissions are in average 13% higher than PN23, but still well below the EURO 6 limit for PN23 (Figure 2).

The CO_2 emissions are in average 165.3 g/km.

4 Conclusions

A demo vehicle from CRF was tested in the laboratory in WLTC cold-start conditions. All pollutants were below the EURO 6 limits.

In particular, the PN23 emissions are two orders of magnitude below the limit of 6×10^{11}/km. PN10 emissions were in average 13% higher than PN23.

The CO_2 emissions were in average 165.3 g/km.

List of abbreviations and definitions

CO	Carbon monoxide
CO_2	Carbon dioxide
CRF	Centro Ricerche Fiat
CVS	Constant Volume Sampler
JRC	Joint Research Centre
NO_x	Nitrogen oxides
PN	Particle Number
REESS	Rechargeable Electric Energy Storage System
RCB	REESS Charge Balance
THC	Total Hydrocarbons
VELA	Vehicle Emissions Laboratory
WLTC	World Harmonised Light duty vehicle Test Cycle

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

- at the following standard number: +32 22999696, or

- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from EU Bookshop at: https://publications.europa.eu/en/publications. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

KJ-NA-30007-EN-N

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub

ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

Publications Office of the European Union

doi: 10.2760/91708

ISBN 978-92-76-14095-5